
Rebuilding terrestrial ecosystems after the end-Devonian mass extinction: insights from the TW:eed Project

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The TW:eed (Tetrapod World: early evolution and diversification) project is a major research initiative that will generate a coherent picture of the biotic, environmental and geological conditions of the 15-20 million years recovery period following the major extinction event at the end-Devonian that was a major turning point in terrestrial evolution. A paucity of terrestrial invertebrates and few fossils of early tetrapods have been found in post-Devonian successions from the immediate aftermath (Romer's Gap) and yet, during a relatively brief time period in the Early Carboniferous, fully terrestrial vertebrates evolved, terrestrial arthropods radiated, ray-finned fishes took over from lobe-finned forms and plant groups diversified. Several new localities in Carboniferous successions in southern Scotland and northern England are providing completely new insights into this pivotal period for the evolution of life on land. Significant new tetrapod material is helping to populate Romer's Gap. Localities are also yielding a diverse fauna of fish (gyracanthids, lungfish, rhizodonts and actinopterygians), invertebrates (malacostracans, eurypterids, ostracods, scorpions and myriapods) and plants. The fossil localities are within the Ballagan Formation, a distinctive unit comprising mudstones with interbedded sandstones, palaeosols and thin beds of dolomitic "cementstone". The sediments were deposited on an extensive low relief, muddy, vegetated floodplain that was traversed by numerous river systems. Periodically the river-derived floods submerged the floodplains generating extensive shallow freshwater lakes. The presence of gypsum and anhydrite indicates that there were occasional marine transgressions across a marginal coastal plain. So far, most of the fossils have been found towards the top of the Ballagan Formation, but a coastal exposure of the entire formation provides a unique opportunity to search for fossils across a time interval of about 15 million years at the base of the Carboniferous.

In addition to the detailed analysis of key outcrops, a drilling program in the Tweed Basin is in the process of acquiring 500 m of continuous core through these earliest Carboniferous successions. A tight stratigraphic framework for tetrapod localities across the region will be generated by integrating the sedimentological (lithostratigraphy), micropalaeontological (biostratigraphy), chemostratigraphical (carbon and oxygen stable isotopes) and petrophysical data from the core and outcrops. The borehole will provide the high-resolution datasets required to investigate the local, and potentially, global palaeoclimate and its evolution through this time interval. This multifaceted project is a unique opportunity to examine the progression, causes and context of the rebuilding of an ecosystem following a major extinction.